Remote Underwater Robotic Inspection

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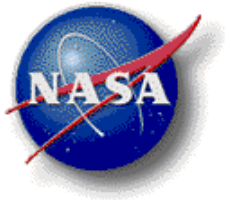
Robotic Systems Technology Branch

Presentation Overview

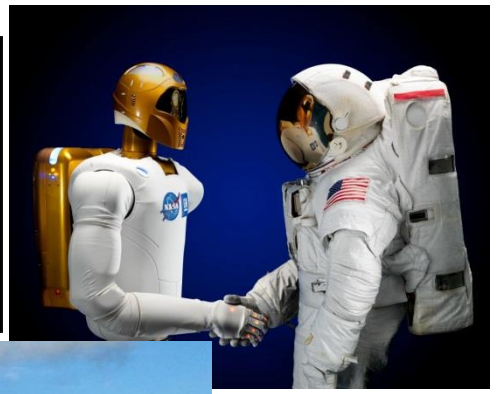


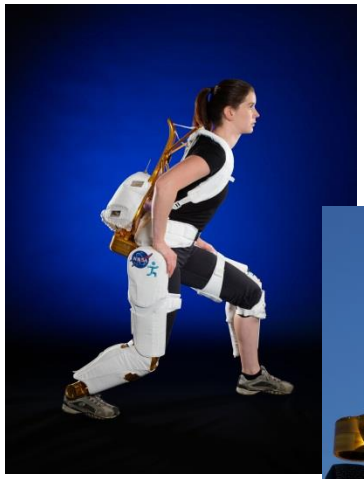
- Overview of Robotic Systems Technology Branch
- Project Background – Robot Inspection
- Hardware Description
- Operator Console
- Testing

- Q & A

JSC - Robotic Systems Technology Branch

- Multi-disciplinary group
- Diverse Range of Robots
  - Dexterity
  - Mobility
  - Wearability
  - Sensing/Inspection
  - Teleoperation & Telepresence
  - Autonomy & Control Systems

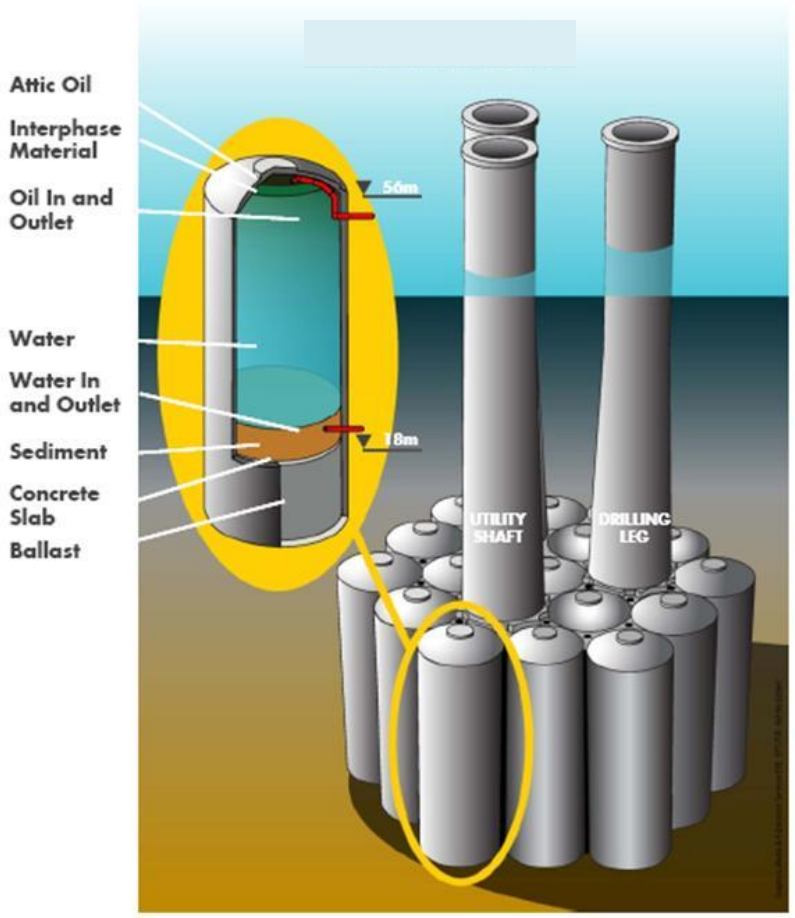



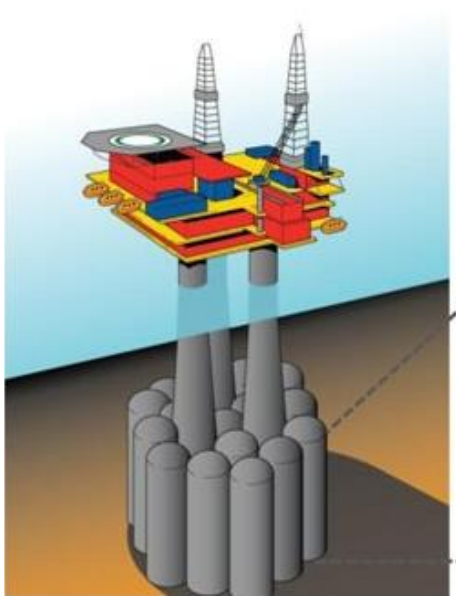

Project Background

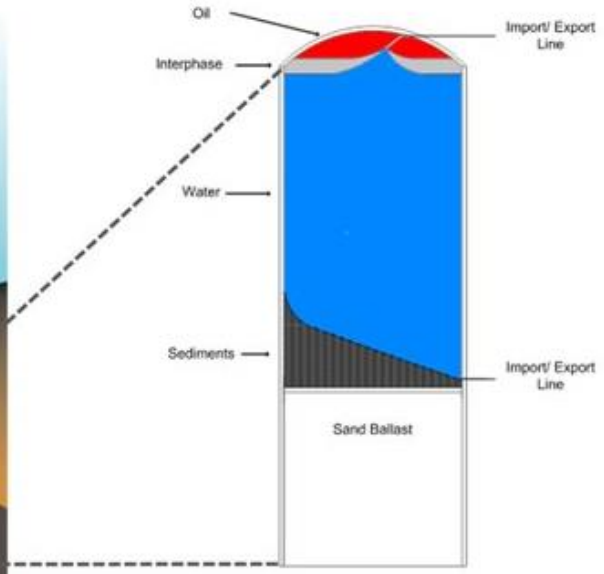
- **Approached by O&G industry to map sediment layer in crude oil storage cells**
- **Space Act Agreement initiated 4/2013**
- **Two phase project**
- **Phase I - Map sediment layer in crude oil storage cell**
- **Phase II – collect sample of sediment layer**
- **5 member project team at JSC**
- **Phase I hardware delivered 11/2013**

Function of Inspection Robot

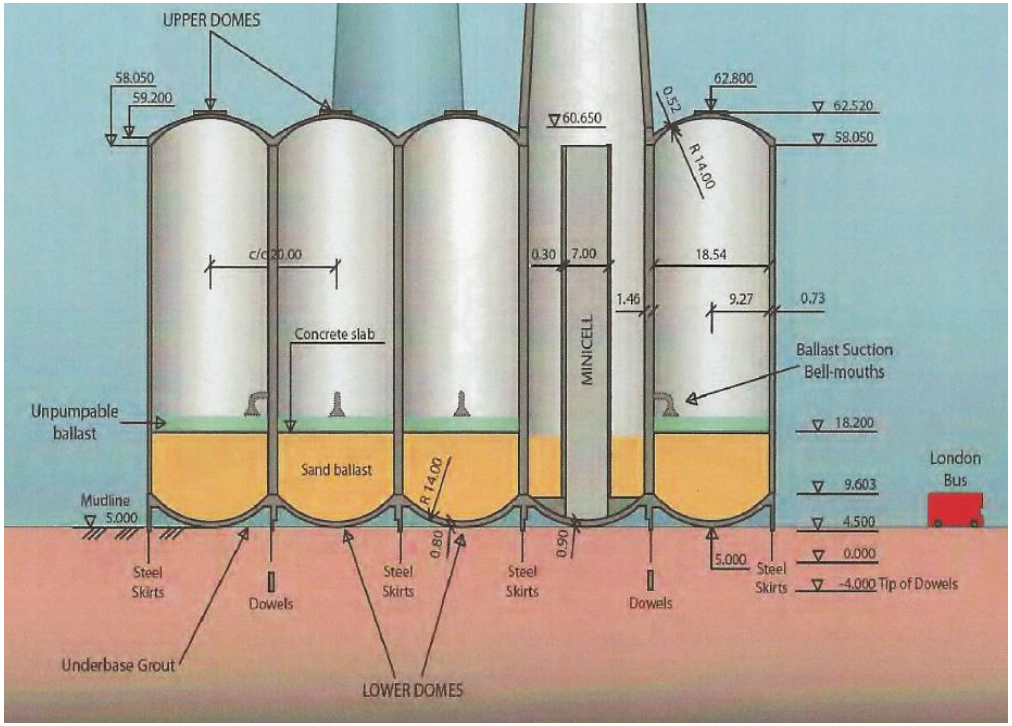
- Gain access to cell via existing 10” fill lines
- Introduce sonar mapping unit into fill lines through hot tap gate valve
- Tethered sonar propelled through pipe work via 4” forced water delivery
- Manual deploy and retrieval via tether spool external to gate valve

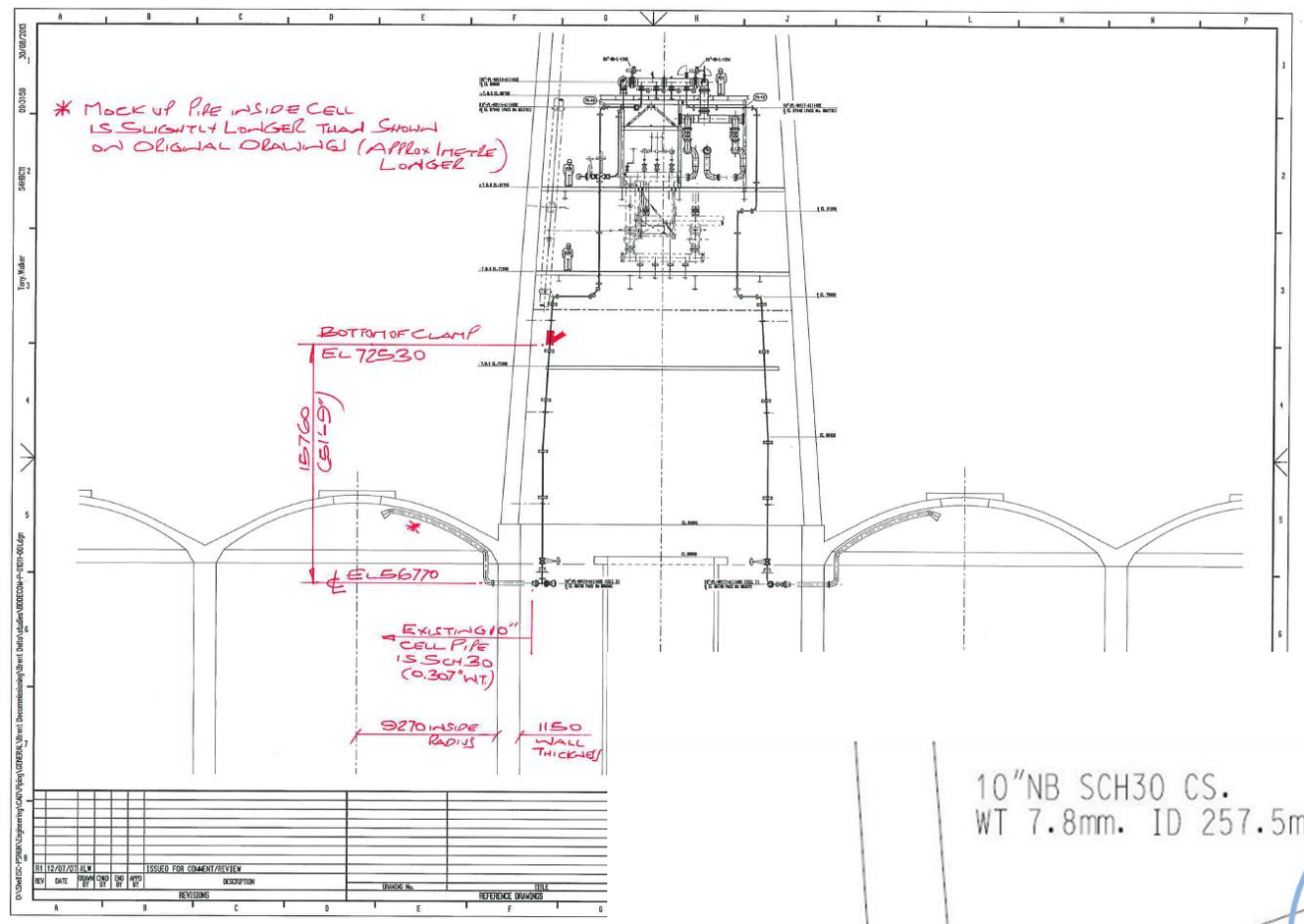


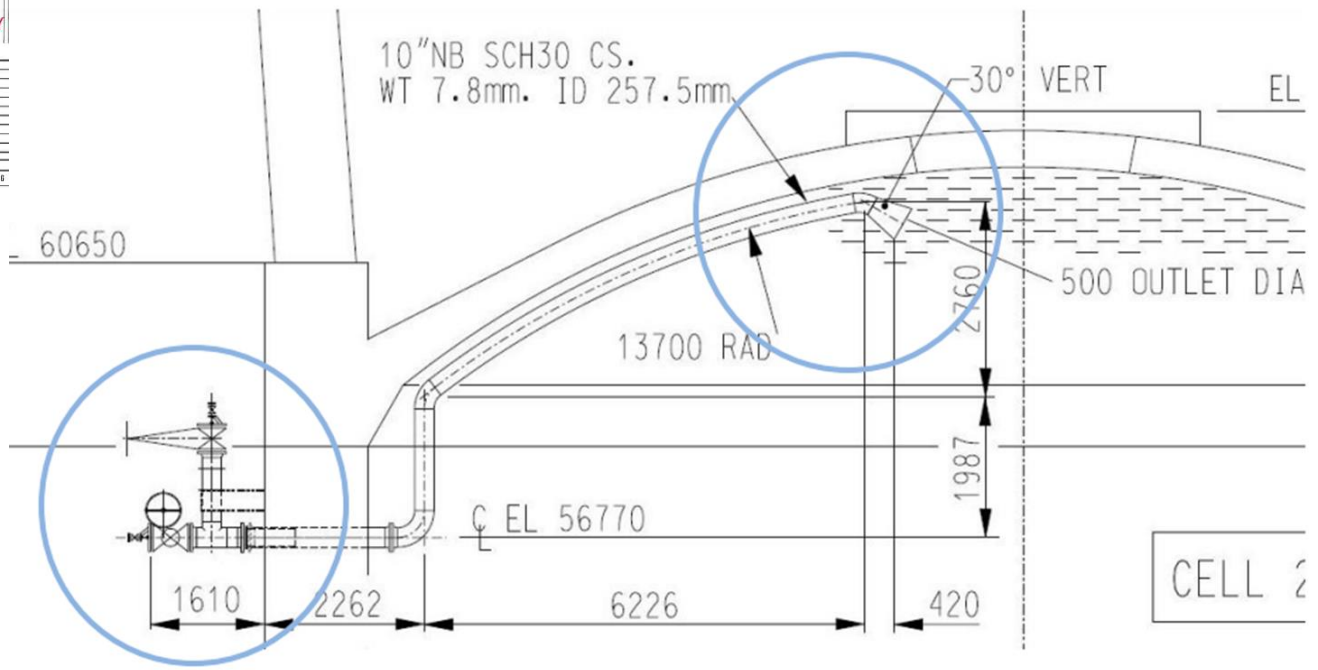




Utility Leg and
Oil Storage Cells

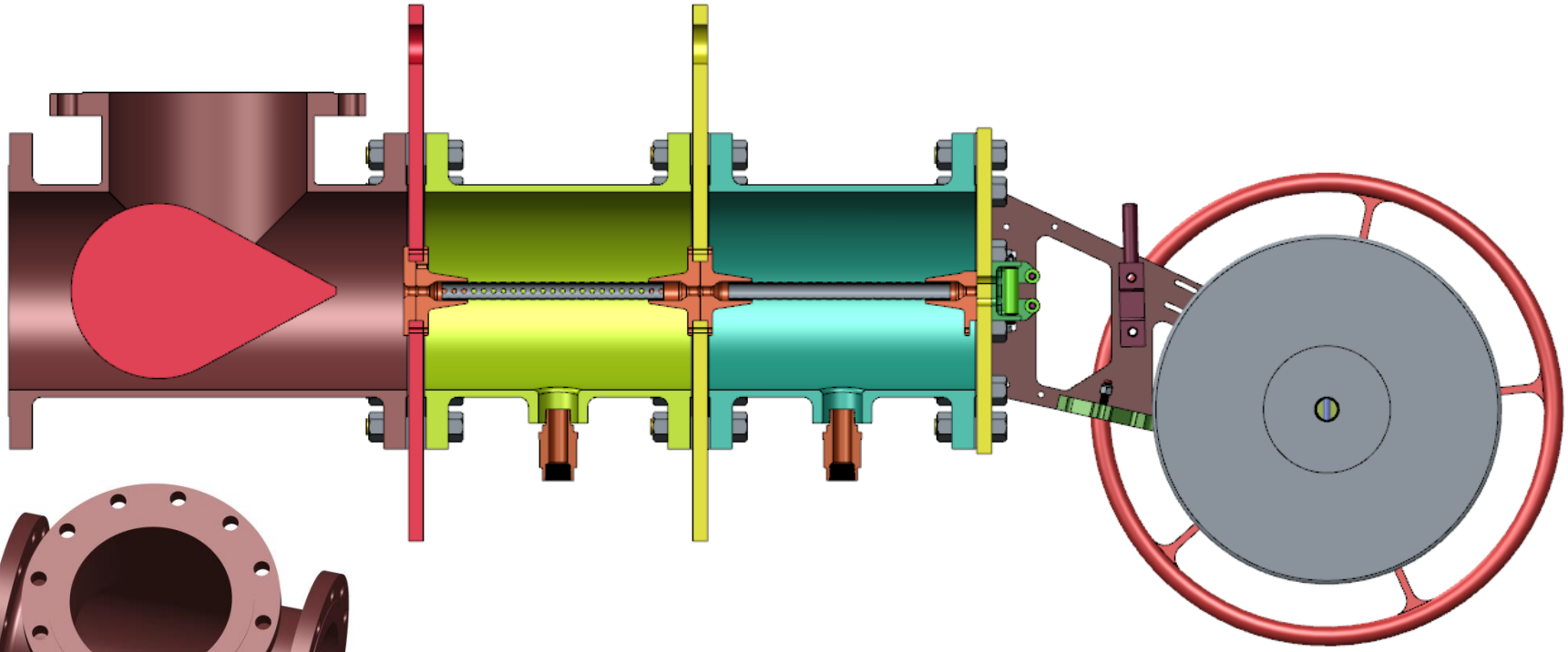



* MOCK UP PIPE INSIDE CELL IS SLIGHTLY LONGER THAN SHOWN ON ORIGINAL DRAWING (APPROX 1METRE LONGER)
BOTTOM OF CLAMP EL 72530
1E760 (CL TO CL)
℄ EL56770
EXISTING 10" CELL PIPE 1.5 SCH 30 (0.307" WT)
9270 INSIDE RADIUS
1150 WALL THICKNESS
R1 12/07/07 ALW ISSUED FOR COMMENT/REVIEW
REV DATE REVISIONS DESCRIPTION
DRAWING No.
TITLE
REFERENCE DRAWINGS


10"NB SCH30 CS.
WT 7.8mm. ID 257.5mm.
30° VERT
EL
60650
500 OUTLET DIA
13700 RAD
2760
1987
℄ EL 56770
1610
2262
6226
420
CELL 2

Concept of Operation

Stuffing Box Internal

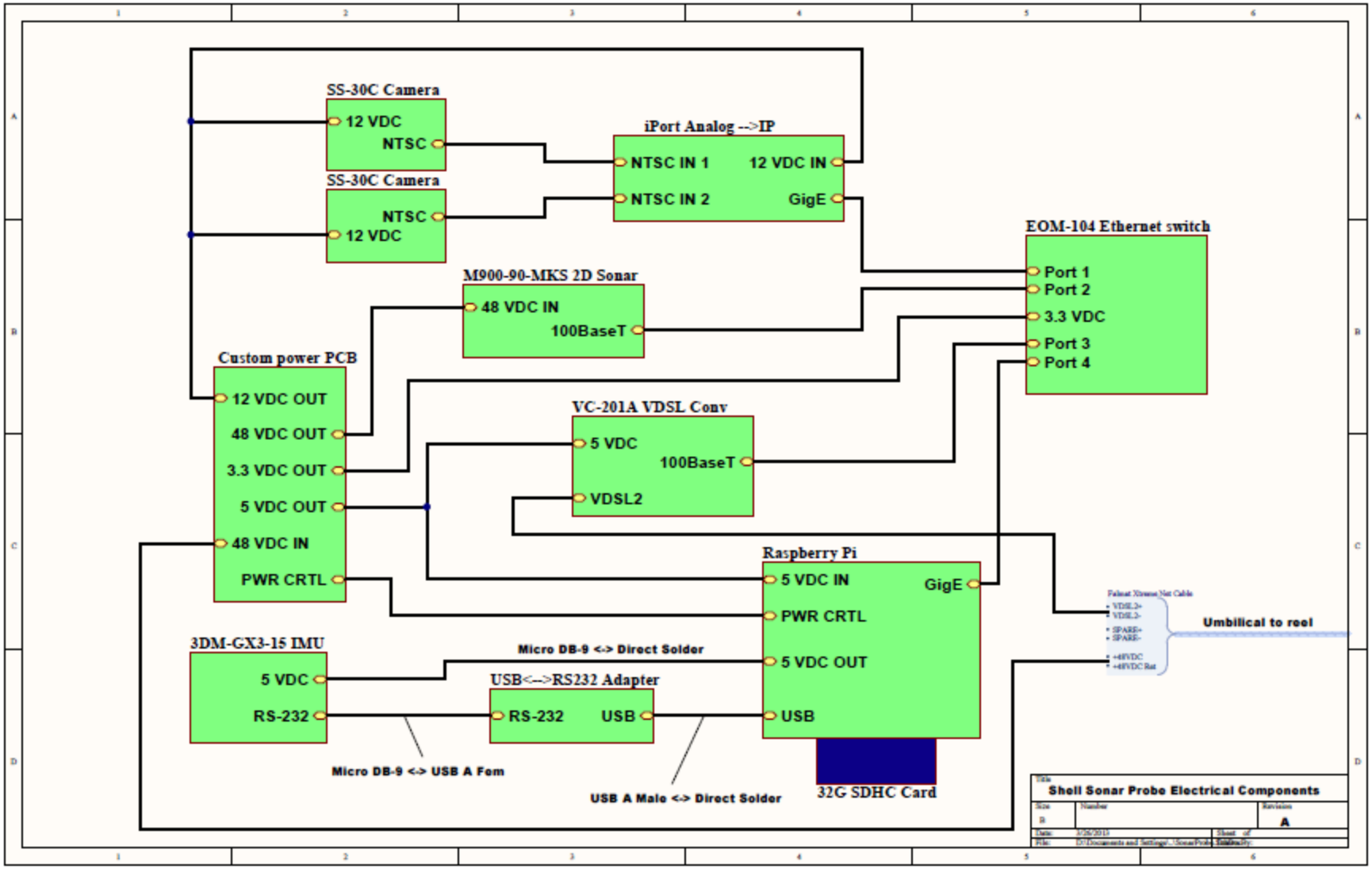


GHT

Inspection Hardware Description

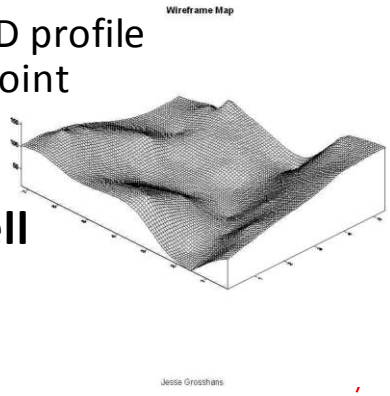
- 9” diameter housing
- 900 MHz 2-D Sonar
- Dual cameras (forward and rear facing)
- Inertial Measurement Unit
- Temperature Sensor
- On-board power converter
- On-board microprocessor
- Video converter
- Ethernet to VDSL converter
- 100m Power/Data tether
- ATEX zone 1 ExD rated hardware

Inspection Robot Block Diagram

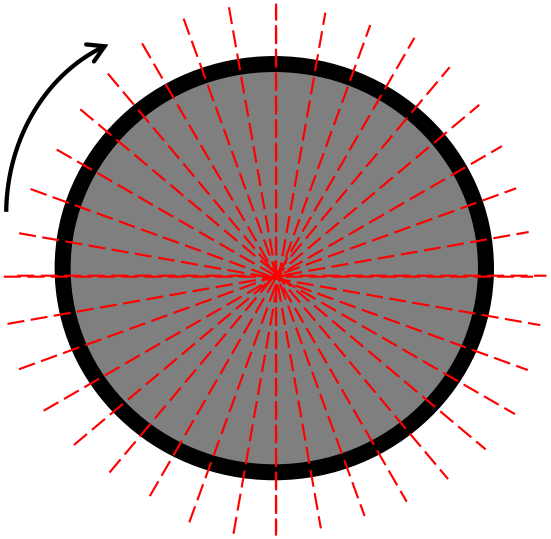


Sonar scan operation

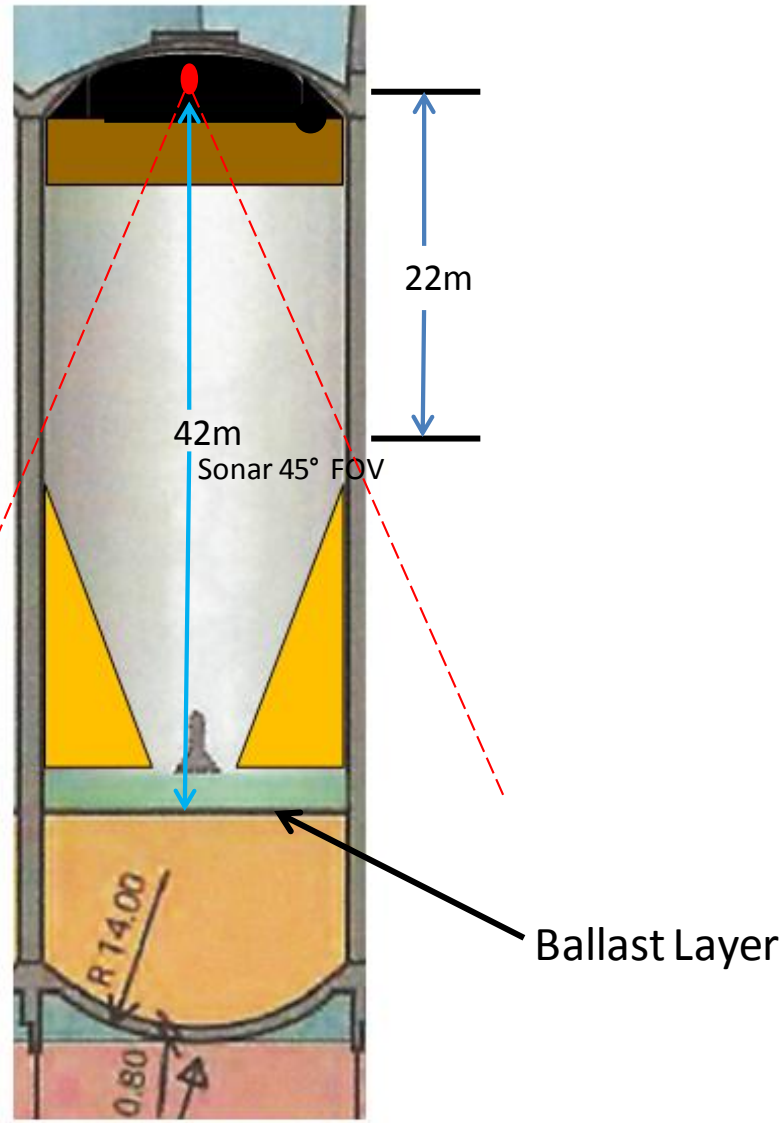
- Sonar suspended top center of storage cell, looking down
- Sonar measurement provides a thin slice profile of the sediment layer (topography accuracy +/- 10cm) across entire width of cell
- Multiple profile images are created as sonar is incrementally rotated about the median-sagittal plane of the storage cell
- A Software composite of the 2D profile images creates a 3D volume (point cloud elevation map)



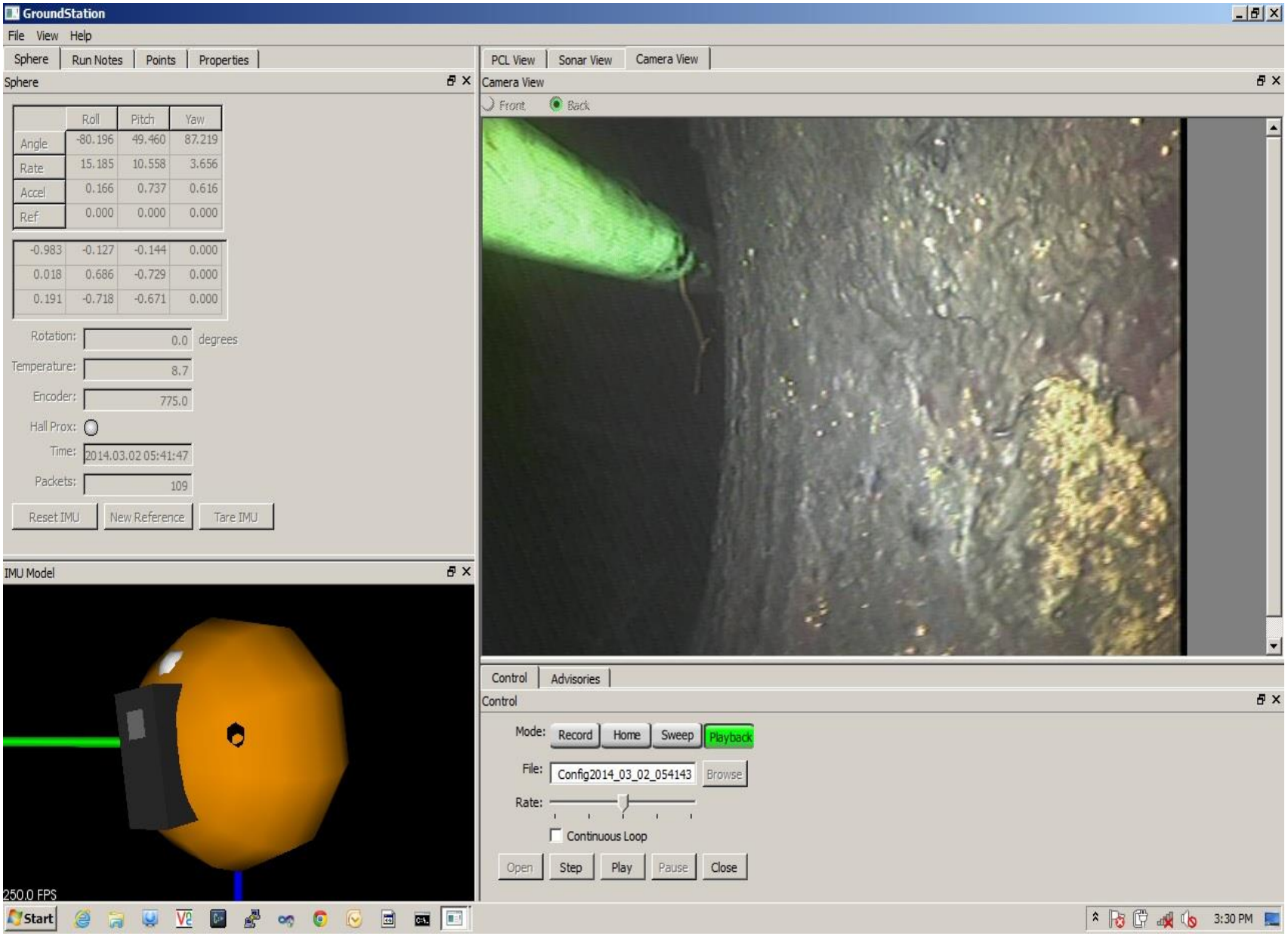
Top view looking down into Cell



Sonar incrementally (1°) rotates through 180°

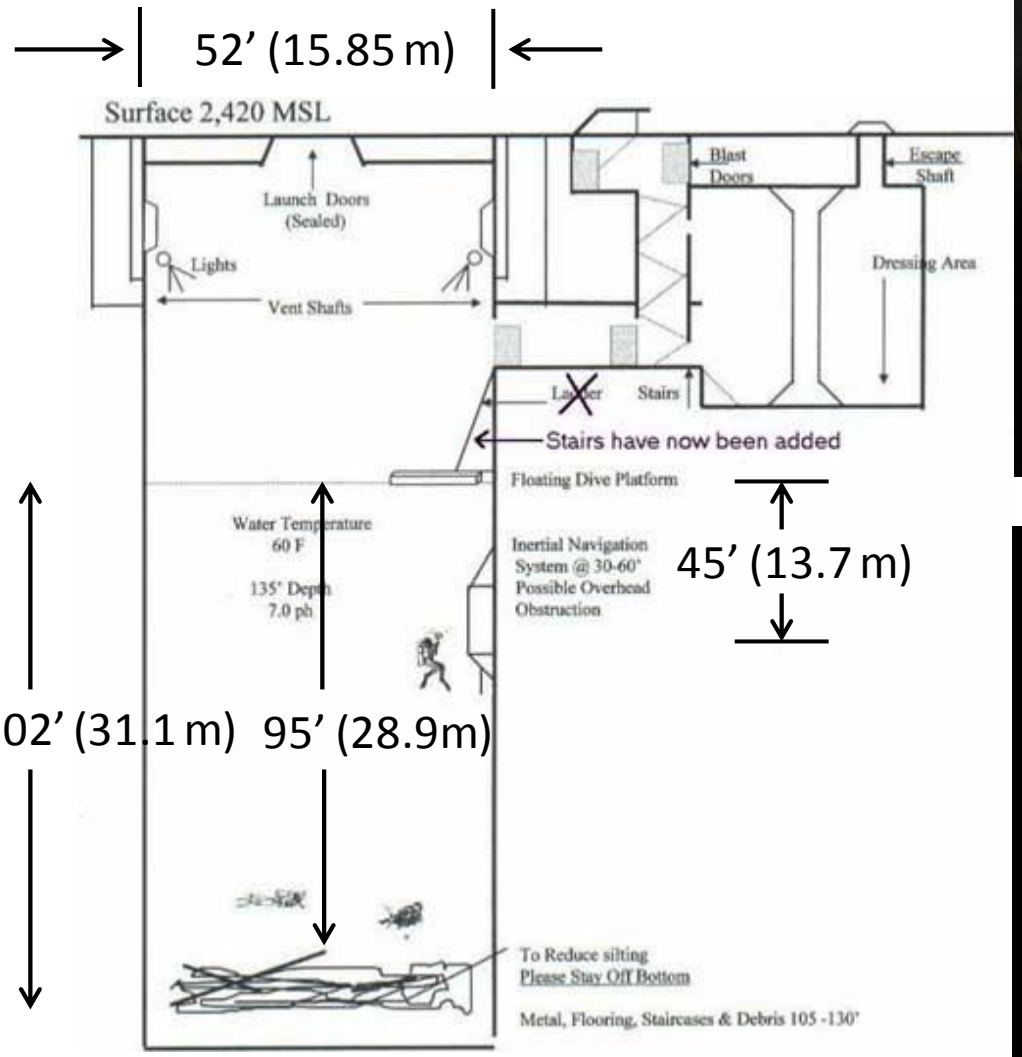


Operator Console

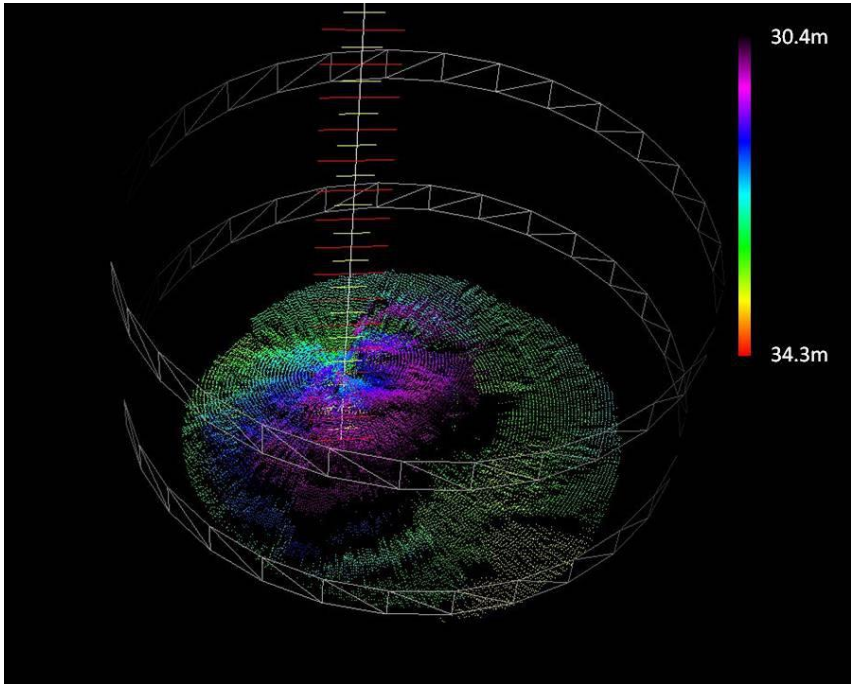


Sphere data at stall point/bellmouth

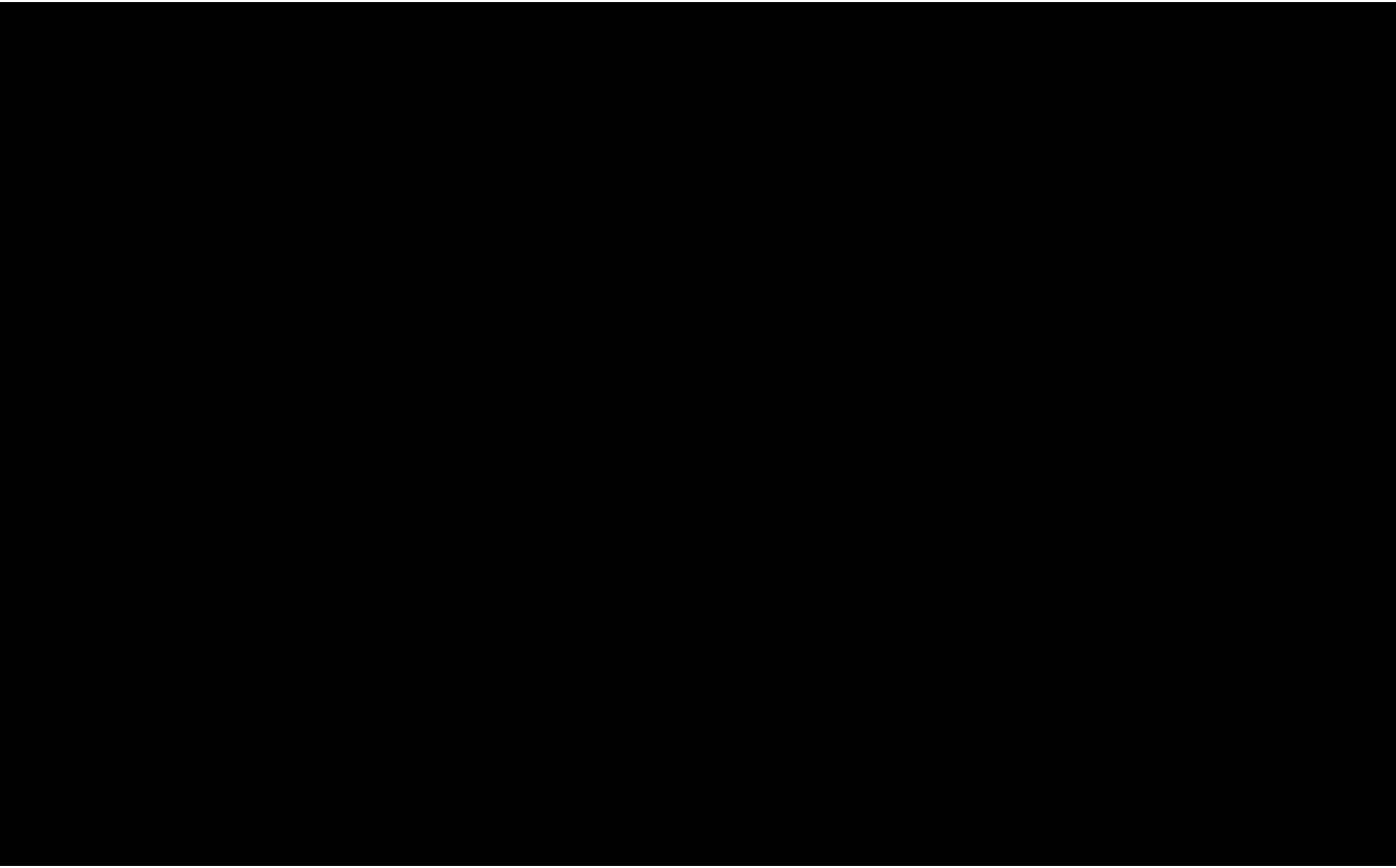
Testing - Valhalla Missile Silo – Abilene, TX



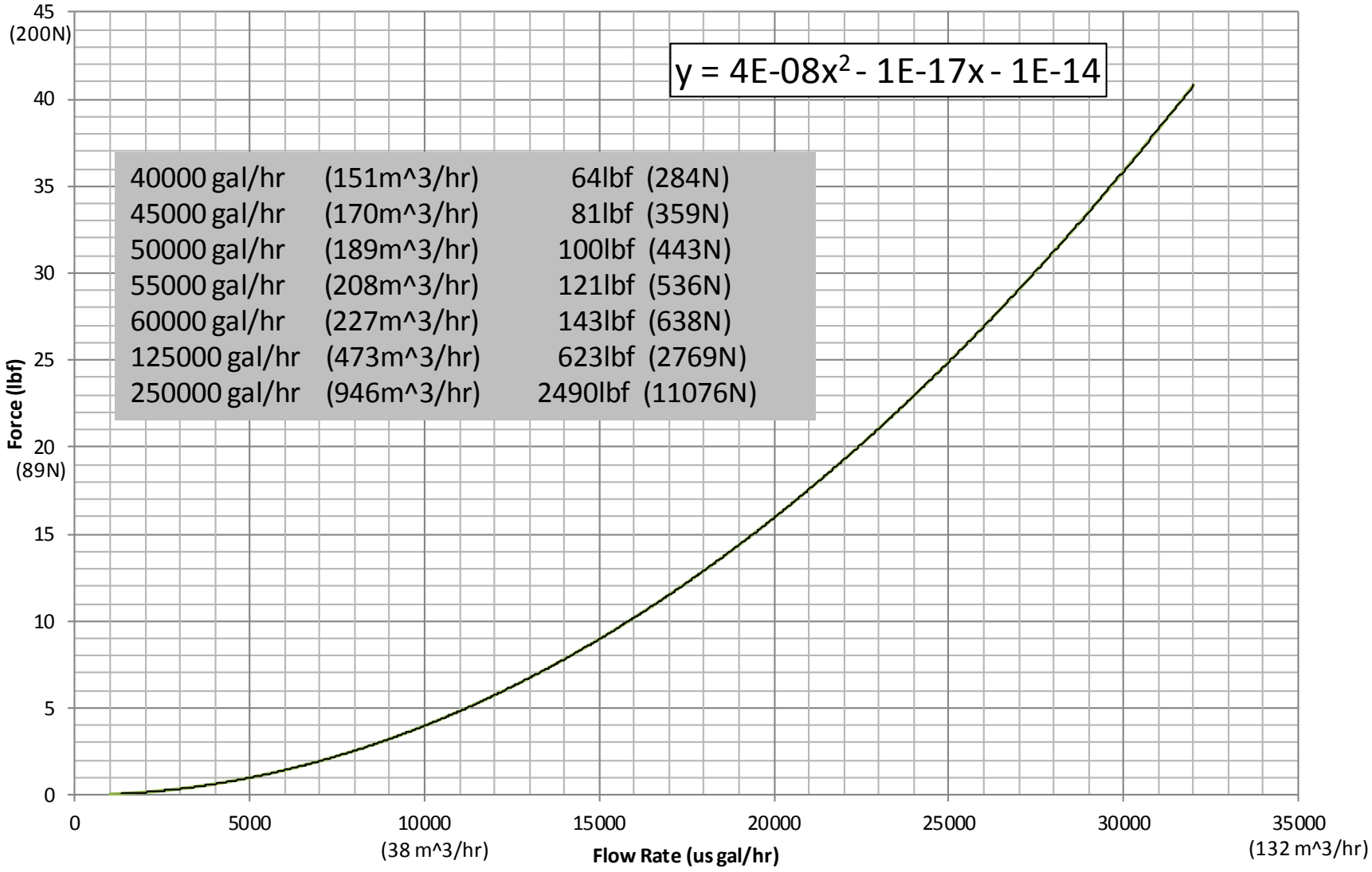
Non-structured, scattered debris at bottom of silo

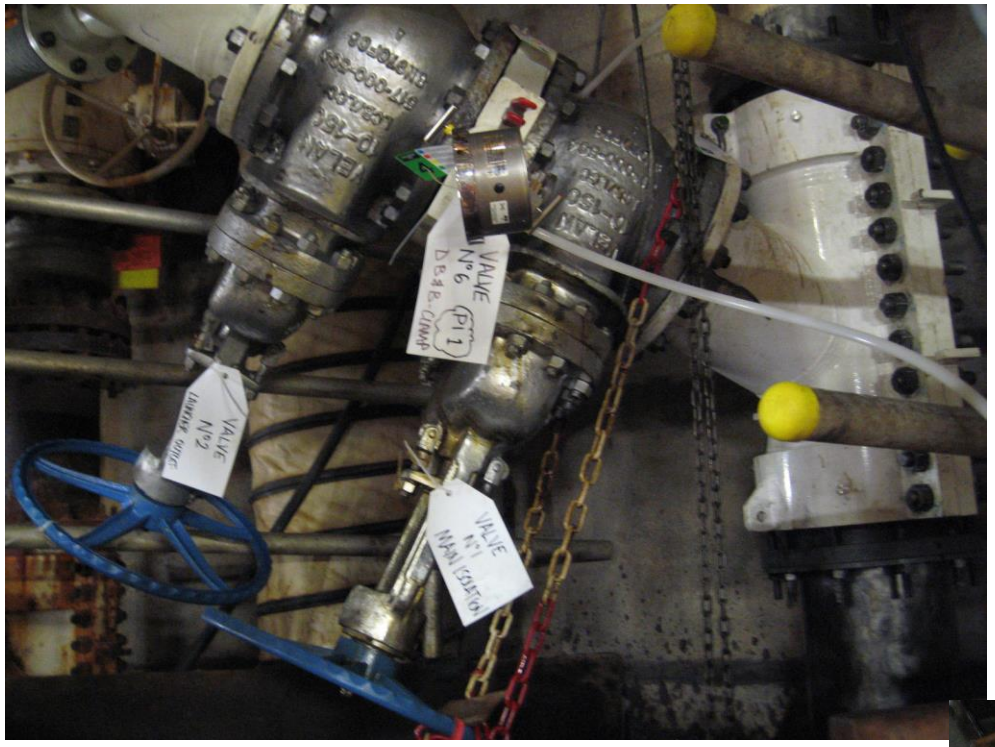


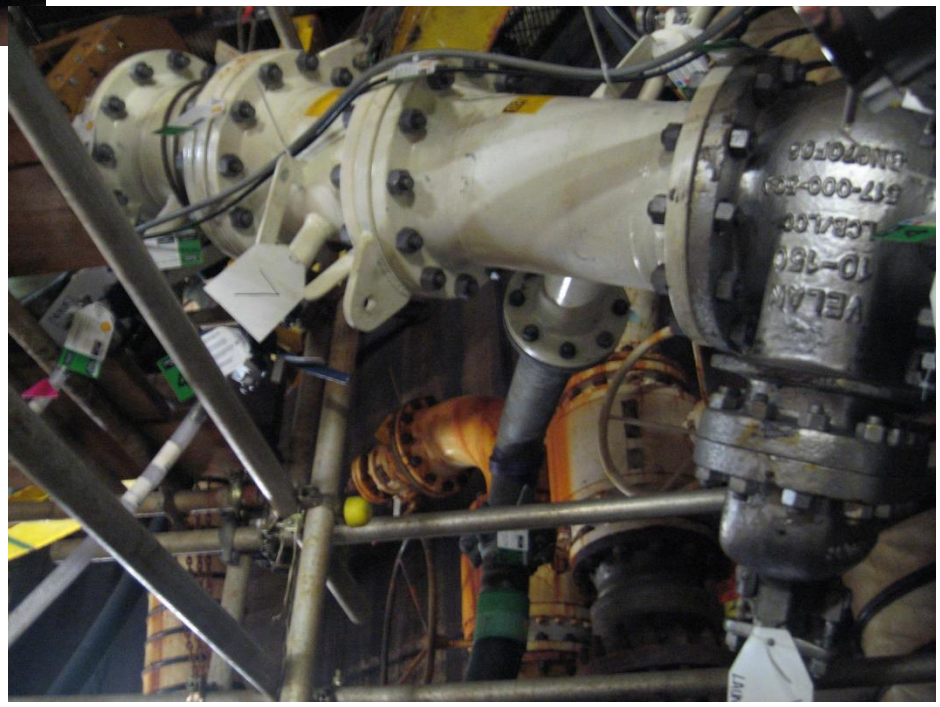
NBL Flow Testing

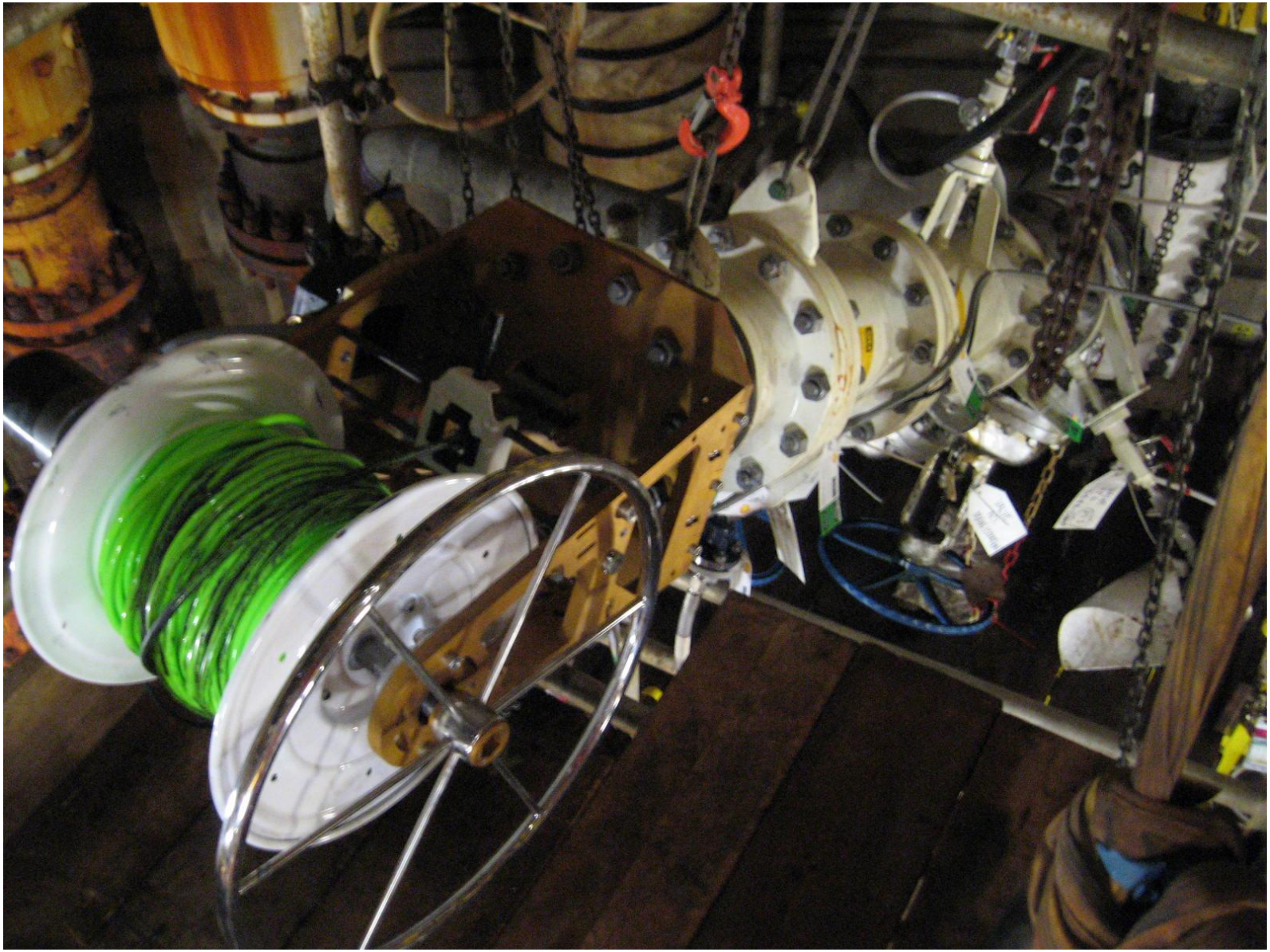


Flow rate vs. Forces




VALVE
N°6
(P1)
VALVE
N°2
VALVE
N°1





Q & A